Exhibit 6

Basic Econometrics

Fifth Edition

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McGraw-Hill Irwin

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BASIC ECONOMETRICS

This book is printed on acid-free paper.

1 2 3 4 5 6 7 8 9 0 VNH/VNH 0 9 8

ISBN 978-0-07-337577-9
MHID 0-07-337577-2

Publisher: *Douglas Reiner*
Developmental editor: *Anne E. Hilbert*
Editorial coordinator: *Noelle Fox*
Associate marketing manager: *Dean Karampelas*
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Media project manager: *Srikanth Potluri, Hurix Systems Pvt. Ltd.*
Cover design: *Brittany Skwierczynski*
Typeface: *10/12 TimesNewRomanPS*
Compositor: *ICC Macmillan Inc.*
Printer: *R. R. Donnelley*

Library of Congress Cataloging-in-Publication Data

Gujarati, Damodar N.
Basic econometrics / Damodar N. Gujarati, Dawn C. Porter. — 5th ed.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-07-337577-9 (alk. paper)
ISBN-10: 0-07-337577-2 (alk. paper)
1. Econometrics. I. Porter, Dawn C. II. Title.
HB139.G84 2009
330.01′5195—dc22

2008035934

Chapter 13

Econometric Modeling: Model Specification and Diagnostic Testing

> Applied econometrics cannot be done mechanically; it needs understanding, intuition and skill.[1]
>
> . . . we generally drive across bridges without worrying about the soundness of their construction because we are reasonably sure that someone rigorously checked their engineering principles and practice. Economists must do likewise with models or else attach the warning "not responsible if attempted use leads to collapse."[2]
>
> Economists' search for "truth" has over the years given rise to the view that economists are people searching in a dark room for a non-existent black cat; econometricians are regularly accused of finding one.[3]

One of the assumptions of the classical linear regression model (CLRM), Assumption 9, is that the regression model used in the analysis is "correctly" specified: If the model is not "correctly" specified, we encounter the problem of **model specification error** or **model specification bias.** In this chapter we take a close and critical look at this assumption, because searching for the correct model is like searching for the Holy Grail. In particular we examine the following questions:

1. How does one go about finding the "correct" model? In other words, what are the criteria in choosing a model for empirical analysis?
2. What types of model specification errors is one likely to encounter in practice?
3. What are the consequences of specification errors?
4. How does one detect specification errors? In other words, what are some of the diagnostic tools that one can use?
5. Having detected specification errors, what remedies can one adopt and with what benefits?
6. How does one evaluate the performance of competing models?

[1]Keith Cuthbertson, Stephen G. Hall, and Mark P. Taylor, *Applied Econometrics Techniques,* Michigan University Press, 1992, p. X.

[2]David F. Hendry, *Dynamic Econometrics,* Oxford University Press, U.K., 1995, p. 68.

[3]Peter Kennedy, *A Guide to Econometrics,* 3d ed., The MIT Press, Cambridge, Mass., 1992, p. 82.

The topic of model specification and evaluation is vast, and very extensive empirical work has been done in this area. Not only that, but there are philosophical differences on this topic. Although we cannot do full justice to this topic in one chapter, we hope to bring out some of the essential issues involved in model specification and model evaluation.

13.1 Model Selection Criteria

According to Hendry and Richard, a model chosen for empirical analysis should satisfy the following criteria:[4]

1. *Be data admissible;* that is, predictions made from the model must be logically possible.
2. *Be consistent with theory;* that is, it must make good economic sense. For example, if Milton Friedman's **permanent income hypothesis** holds, the intercept value in the regression of permanent consumption on permanent income is expected to be zero.
3. *Have weakly exogenous regressors;* that is, the explanatory variables, or regressors, must be uncorrelated with the error term. It may be added that in some situations the exogenous regressors may be **strictly exogenous.** A strictly exogenous variable is independent of current, future, and past values of the error term.
4. *Exhibit parameter constancy;* that is, the values of the parameters should be stable. Otherwise, forecasting will be difficult. As Friedman notes, "The only relevant test of the validity of a hypothesis [model] is comparison of its predictions with experience."[5] In the absence of parameter constancy, such predictions will not be reliable.
5. *Exhibit data coherency;* that is, the residuals estimated from the model must be purely random (technically, white noise). In other words, if the regression model is adequate, the residuals from this model must be white noise. If that is not the case, there is some specification error in the model. Shortly, we will explore the nature of specification error(s).
6. *Be encompassing;* that is, the model should *encompass* or include all the rival models in the sense that it is capable of explaining their results. In short, other models cannot be an improvement over the chosen model.

It is one thing to list criteria of a "good" model and quite another to actually develop it, for in practice one is likely to commit various model specification errors, which we discuss in the next section.

13.2 Types of Specification Errors

Assume that on the basis of the criteria just listed we arrive at a model that we accept as a good model. To be concrete, let this model be

$$Y_i = \beta_1 + \beta_2 X_i + \beta_3 X_i^2 + \beta_4 X_i^3 + u_{1i} \qquad \textbf{(13.2.1)}$$

where $Y =$ total cost of production and $X =$ output. Equation (13.2.1) is the familiar textbook example of the cubic total cost function.

[4]D. F. Hendry and J. F. Richard, "The Econometric Analysis of Economic Time Series," *International Statistical Review,* vol. 51, 1983, pp. 3–33.

[5]Milton Friedman, "The Methodology of Positive Economics," in *Essays in Positive Economics,* University of Chicago Press, Chicago, 1953, p. 7.